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RATIONAL THOUGHT AND RATIONAL BEHAVIOR: A REVIEW OF BOUNDED RATIONALITY: THE ADAPTIVE TOOLBOX

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Standard economic theory says that the rational approach to a decision is to weigh all alternatives on all relevant dimensions and then to select the one with the highest weight. Such a procedure would maximize subjective expected utility. But, because of constraints on time and available information, people and other animals often bypass this process by using ''fast and frugal'' heuristics to make decisions. Rationality is thus said to be ''bounded'' by time and information constraints. The articles in this book describe and organize common heuristics. They show that use of such heuristics is generally the best approach to many real world problems and therefore not irrational. Heuristics evolved, they say, not as deviations from rationality but as aids to rationality in cases where the standard model would have proved to be too slow or inefficient. Although the approach of almost all of the authors of these papers is that of cognitive psychology—a focus on internal cognitive mechanisms—their findings and even their theories may be interpreted in terms of reinforcement and punishment acting on behavioral patterns.

Key words: choice, decision, economics, heuristics, rationality, rules

In 1956, Herbert Simon published a *Psychological Review* article entitled ''Rational choice and the structure of environments.'' In it he introduced the notion of *satisficing,* a form of utility maximizing in which constraints of time and effort apply not only to behavior but also to an internal decision process supposed to govern behavior. Even though in theory it might be possible to make a perfect decision, a *rational* decision, by means of very complex calculations taking lots of time and effort, real-world decisions, according to Simon, are made using *fast and frugal* heuristics, rules of thumb, that would *satisfice* (meet some less than perfect criterion) rather than maximize utility over the long run. Rationality is said to be *bounded* by these internal constraints. According to Simon, fast and frugal heuristics would be conscious processes or at least accessible to introspection in humans. Simon's subsequent research has explored introspective techniques and analysis of verbal reporting (Ericsson & Simon, 1984). But in nonhumans, heuristics would have evolved as unconscious mechanisms governing choice. According to Simon, the job of a psychology of decision making is to codify and document these heuristics in humans and nonhumans, to help apply them to situations where they work well, and perhaps to help people to avoid applying them in situations for which they are unsuited.

This book, the output of a workshop held in Berlin almost half a century after the publication of Simon's *Psychological Review* article, represents the latest development of his plan. According to the editors, ''this book . . . cannot and will not provide a unified theory of bounded rationality. Rather its goals are (a) to provide a framework of bounded rationality in terms of the metaphor of the *adaptive toolbox,* (b) to provide an understanding about why and when simple heuristics in the adaptive toolbox work, (c) to extend the notion of bounded rationality from cognitive tools to emotions and (d) to extend the notion of bounded rationality to include social norms, imitation, and other cultural tools'' (p. 1).

An example of an adaptive tool cited in several of the articles is simple recognition (Goldstein & Gigerenzer, 1999). American college students recognize the names of only about half of the 83 largest German cities. If they decide simply on the basis of recognition which one, in a pair of these cities, has the larger population (guessing when recognizing both or neither) they can do pretty well

Gigerenzer, G. & Selten, R. (Eds.). (2002). *Bounded rationality: The adaptive toolbox.* Cambridge, MA: MIT Press.

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(67%). Adding other cues raises accuracy only slightly and may actually decrease performance. In the reverse case, German students did better than American students in guessing whether San Diego or San Antonio was the larger city (100% vs. 62%) presumably because the Americans, recognizing both cities, had to use other cues or just guessed while the Germans could sort the cities purely by recognition.

Another example, also frequently cited in this book, is Tversky's (1972) *elimination by aspects*. Say you are buying a car. You decide among the alternatives on the basis of the single aspect that is most important to you (price, for instance) and eliminate all alternatives that fail to meet your (price) criterion. Then you go to the next most important aspect and repeat the process, and so on, until you are left with only one alternative. As Tversky showed, this process may yield intransitive choices—as opposed to the normative process of assigning a weight to each aspect, evaluating all alternatives on all aspects simultaneously, and choosing the alternative with the highest total weight. For many practical real world decisions, however, elimination by aspects works as well as the more complex normative model.

Real-world decisions take into account not only the constraints imposed by the environment (including probability and reward discounting) but also the constraints imposed by the thinking process itself: the inability of the brain (conceived as a computer) to perform numerous calculations in a short time as well as the limited information obtained by the decision maker (who must ration time spent obtaining that information). According to the contributors to this volume, however, once these extra-environmental constraints are factored in, decision making is rational after all—but boundedly rational.

The book is divided into four sections corresponding to its four aims quoted above. Each section has three or four articles followed by a group report. The first section presents some basic heuristics (tools from the adaptive toolbox), organizes them, and develops a few general principles. It is clear that simple verbal report has been abandoned in this field for the standard techniques of cognitive psychology. According to Selten, ''even thinking is based on automatized routine'' (p. 16) and thus may not be accessible to consciousness. This first section tackles the problem of infinite regress. If you have an adaptive toolbox containing a number of heuristics with which to solve problems, which one do you use in any given case? You need a heuristic to select among heuristics, another heuristic to select among those, and so on ad infinitum. Selten solves this problem by assuming that people will first determine their aspiration level (the degree of satisfaction they expect to get by solving the problem) and then select a heuristic to deal with it based on past experience with this sort of problem. If, as Selten claims, the selection and operation of heuristics need not be conscious or even accessible to consciousness, a *heuristic* is what behavioral researchers have called a *rule*. That is, both heuristics and rules are temporally extended relations between behavior and environment that can be learned by nonverbal as well as verbal animals.[1] And, the claim that heuristics are selected by past experience is equivalent to the claim that rule-following may be reinforced (see the various articles in Hayes, 1989). Thus, Selten's theory may be translated to one based on reinforcement.

The second section of the book compares heuristics with optimal models of choice and finds that optimal models do not work as well as heuristics. Why? Because in a sense (taking time and information constraints into account) heuristics are more optimal than optimal models are. This ambivalence between heuristics and optimization runs throughout the book.

The third and fourth sections deal with emotional, social, and cultural influences on decision processes. These sections contain a variety of interesting but generally unrelated articles on human and nonhuman choice. One, by Thomas Seeley, describes how a cluster of bees decides which of several new-hive alternatives (presented in the form of waggle dances by scouts indicating distance, direction, and suitability) to choose. The title of this article is, ''Decision making in superorganisms: How collective wisdom arises from the poorly informed masses.'' The idea is that very simple processes in individual organisms

[1] Baum (2002) has recently argued that such relationships are the basic units of reinforced behavior.

can result in wise decisions on the group level. This sounds like the invisible hand (the basis of standard, non-boundedly rational macroeconomic theory) at work.

Another article, by Ido Erev and Alvin Roth, claims that, for an individual, the highly simple processes of reinforcement and punishment (recognize the words?) can explain apparently complex strategies in repeated prisoner's dilemma games. Their model is a standard mathematical utility maximization model where the elements are not individual acts but patterns of acts. They show that a ''forgiving mode'' that reciprocates cooperation and defection on the basis not only of the prior trial but also of the one before that—so that a defection may be corrected without being immediately punished and is thus ''forgiven''—is an excellent description of actual performance in prisoner's dilemma games.

Another game theory study is that of Kevin McCabe and Vernon Smith. This article incorporates what the authors call ''goodwill accounting'' into the game's explanation. Over a series of games, according to the authors, players give and receive a degree of trust. When they cooperate (or otherwise act for the other player's benefit) they add to a store of goodwill which is then reflected in the other player's behavior because in the long run goodwill is so valuable it is worth the expense of time and effort for one player to reward or punish another when an exchange pattern is completed or violated. Quantification of this exchange of goodwill enables the authors to explain individually irrational but nevertheless group-beneficial behavior.

Both the Erev and Roth and McCabe and Smith articles contain interesting variations on standard game-theory analysis; ones that bring theory much closer to real-world behavior than it was before. The difference between them is that while Erev and Roth couch their theory in the language of reinforcement and punishment, hence utility maximization (Rachlin, 1994), McCabe and Smith add a cognitive model to their analysis. The flow diagram of this model has 13 boxes of four kinds with 26 arrows, also of several kinds. Inside the several boxes are labels such as ''mind reading,'' ''myopic self-interest,'' and ''cheater detection,'' with references to other authors who presumably could fill them in with equally complex submechanisms. The goal of understanding the decision making process in terms of computer software and eventually neurophysiological hardware is a laudable one. But we are a long way from that goal. Instead, behavioral readers may be tempted to think of the concept of goodwill in terms of temporally extended contingencies rather than the current state of internal mechanisms.

Research in my own laboratory has looked at the behavioral side of this question (Baker and Rachlin, 2002). Players' choices in prisoner's dilemma games are sensitive not only to direct contingencies of reinforcement and punishment imposed by the other player but also to the other player's contingencies; players reinforced or punished their opponent's choices so as create favorable conditions for themselves. Sensitivity to the contingencies faced by another player is the same as sensitivity to a more abstract and temporally extended set of the player's own contingencies. As a player's contingency sensitivity becomes more and more extended, there will be more and more occasions when the player's choice (to cooperate) benefits an opponent and violates the rational immediate choice (to defect) which would have produced the higher immediate reward but have harmed the opponent. Choices to cooperate, if part of a consistent reinforcement strategy, may thus constitute goodwill. This analysis is, of course, ad hoc and may not be ultimately useful. Its function here is only to illustrate how much more interesting it would have been to behaviorists if McCabe and Smith had traced goodwill exchange, not into the organism, but into patterns of reinforcement and punishment over time.

Other articles in this collection suffer from the same problem. First the heuristic is found and its function clarified. Then it is reified and placed in the subject's head. For example, several of the articles in the last section point out that imitation is a pervasive and useful behavioral pattern throughout nature. So far so good. But does that mean we have an innate imitation mechanism in our brains? Or does it mean that imitation itself is a frequently reinforced behavior pattern? Unfortunately, the former conclusion is drawn in this book, thereby closing off thought about more complex cases of social control where

at times the exact opposite of imitation is reinforced, as in Bell and Baum's (2002) studies of the distribution of flocks of pigeons at multiple food sites or my searching for a parking space in New York City.

The problem perhaps stems from the fact that the authors of the articles in this book are fighting a war on two fronts. On one front, they argue against those cognitive psychologists who see heuristics and biases as fundamental irrationalities built into the human mind. On the contrary, the present authors claim, speed and frugality are just what we need to make the best decisions we can in the real world. I believe that this argument is correct.

On the other front, though, they oppose the standard economic model that sees rational man acting rationally in all situations. They note that every decision is not the best of all possible decisions, and conclude from this undisputed fact that, contrary to standard economic theory, utility is not maximized. This conclusion, it seems to me, is a mistake. What should be rejected is not rationality in the form of utility maximization but rationality in the form of a logic machine in people's heads. The concept of maximization of expected utility does not necessitate a logic machine in the head. Maximization is not what the subject of investigation (pigeon or person) is *doing*. It is rather a conceptual tool of the theorist—a way of explaining the behavior of the subject of investigation. It is, in fact, the only tool that economists have. And, it is identical to the behaviorist's conceptual tool of reinforcement (Rachlin, 1994).

One of Simon's metaphors, often referred to in the book, is of a pair of scissors. One blade stands for internal cognitive structure; the other is the external environment. Both are said to be necessary to explain decision making. The problem with this metaphor is that such a pair of scissors cannot cut anything because the blades do not meet. What abuts against the environment is not a cognitive mechanism but overt behavior. With a few exceptions, however, overt behavior is not the focus of interest of the articles in this book.

Just as behaviorists have been able to incorporate the ''misbehavior of organisms'' into standard behavioral theory (in terms of innate patterns, reinforcement of those patterns, and maximization over longer time periods) so, by showing their adaptive usefulness, human heuristics and biases may be incorporated into standard economic theory—amending rather than abandoning the concept of utility maximization. This job remains to be done.

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